ARCADIS Geraghty & Miller

In Situ Chemical Stabilization of Metals and Radionuclides Through Enhanced Anaerobic Reductive Precipitation

Technology Need:

Metal contaminants occur in soil and groundwater at several of the major Department of Energy (DOE) sites. Metals of concern include uranium, chromium, lead, mercury, cadmium, arsenic, and barium. Cost effective means are required to minimize the migration of these toxic metals into previously clean areas or the leaching of these metals into groundwater systems that can spread the contamination. These contaminants have, in many cases, migrated horizontally and vertically to contaminate large areas of the aquifers underlying these sites. Contamination may extend to hundreds of feet beneath the surface. The baseline method for treatment of contaminated soil invariably employs ex situ technology, which is both expensive and fraught with safety challenges during excavation and handling. Also, pump and treat systems are often projected to require as much as 200 years to achieve treatment objectives. Competing in situ technologies under development have proven so far to be either extremely difficult for large-scale in situ subsurface stabilization, incapable of reducing some metals, such as cesium, strontium, etc...., or are excessively high in cost.

Technology Description:

This project builds on ARCADIS Geraghty & Miller's (ARCADIS) successful commercial experience in remediating a variety of metals and chlorinated solvents. Their approach is based on the fact that, as groundwater pollutants move through the subsurface, conditions can be optimized to cause beneficial chemical or physical transformations to occur. Many metals and radionuclides can be reduced to less harmful forms and precipitated irreversibly to prevent migration. In many cases, the metals are returned to their naturally occurring stable mineral form. ARCADIS will demonstrate that indigenous microbiological organisms can be stimulated through controlled addition of molasses to cause the irreversible in situ precipitation of plutonium (Pu), uranium (U), technetium (Tc), and strontium (Sr).

Once a heavy metal has been precipitated and sorbed to the geologic matrix (soil or bedrock), it no longer travels with the groundwater and no longer appears in any downgradient water wells or in monitoring samples taken from the contaminated groundwater plume. Since the chemical transformations involved are not reversible in the natural environment, the pollutants affected cease to be concerns when natural conditions are restored to the aquifer. That is, the process irreversibly and permanently stabilizes and/or removes targeted contaminants.

When presented with a food source, such as the sugars in molasses, bacteria will proliferate. As part of the natural cycle of carbon and oxygen in natural systems, the process also consumes oxygen. The limited availability of oxygen in the subsurface environment soon encourages anaerobic bacteria, also indigenous to the subsurface environment, to continue the consumption of carbon by relying on sulfur compounds in lieu of oxygen. The aquifer is systematically altered chemically to favor the transformation of a variety of contaminants including heavy metals and organic solvents. Molasses diluted with water is easily injected into the contaminated zone of an aquifer where it provides both the carbonaceous food source and sulfate needed for the biochemical reactions that cause the precipitation of target heavy metals. Once treatment objectives are met, addition of molasses will be terminated and the aquifer will return to preexisting conditions through natural processes.

The molasses-induced in situ reactive zone (IRZ) concept has been successfully employed to restore more than 50 sites with a variety of contaminants, but additional work remains to demonstrate the applicability of this approach to U, Tc, Pu, Hg, and Sr under conditions likely to be encountered at DOE sites.

Benefits:

- The reagent itself is 1) competitively available and very economical, and 2) it is food-grade: typically raises no regulatory, public, or stakeholder concerns.

- Potential or demonstrated application to a wide spectrum of metal contaminants such as chromium, cadmium, lead, nickel, zinc, uranium, technetium, mercury, plutonium, and strontium.

- Flexible application - a spectrum of contaminant mass treatment options from passive/containment barrier applications to aggressive source area applications.

- Enhances natural attenuation processes.

- Applicable to various geological settings and aquifer conditions.

- Electron donor source is highly soluble and can move through both diffusive and advective processes into difficult lithologies such as fractured bedrock.

- Flexible design ranging from automated systems to manual bulk application.

Status and Accomplishments:

This is a new project that was initiated in October 2001. The project will be conducted in two phases. Continuation will be evaluated at the completion of Phase I.

Phase I, Full-Scale Laboratory Testing, consists of exploratory and advanced development of the IRZ technology as applied to DOE needs. The efforts will cover a period of one and a half years and will consist of five technical tasks: 1) field sample collection (DOE sites); 2) soil subsampling and column setup; 3) column operation; 4) column breakdown and treated-soil sampling, including decontamination and waste disposal; and, 5) data analysis and preparation of a final report.

In Phase II, Engineering Development (Design) and Field Demonstration, ARCADIS will perform the engineering design for the full-scale demonstration of the IRZ technology at a DOE site. Following the successful design task, a field demonstration of the IRZ technology will be initiated (tentatively planned to be DOE Fernald Site). The effort will cover a period of two and one half years and will consist of five technical tasks: 1) data collection at the field demonstration site; 2) injection and monitoring well installation; 3) reagent injection eighteen different times throughout a one-year period; 4) sampling and monitoring of the test-area groundwater; and, 5) preparation of a final report.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 3162
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit the ARCADIS Geraghty & Miller website at
http://www.arcadis-us.com/